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REVIEW ARTICLE

Biomedical properties of *Prosopis juliflora*

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Abstract

Plants are the repositories of the bioactive principles which are known for their usage in modern and traditional medicine. The bioactive principles act as armoured knights by either preventing or slowing down the degenerative diseases. The efficacy and therapeutic value of the phytocompounds make them very much suitable to serve as leads for drug development. *Prosopis juliflora,* also known as mesquite, is a thorny deciduous plant which is drought resistant and fast growing. *P. juliflora* is well known for its ethnobotanical significance. The abundant number of secondary metabolites present in *P. juliflora* contributes to its therapeutic potential. These phytocompounds attribute to antioxidant, anti-inflammatory, antimicrobial and anticancer properties. This review encompasses the various biomedical properties of *P. julifora* and its applications in the drug development.

Keywords: antioxidant property; bioactive principles; ethnobotanical significance; *Prosopis juliflora*

Introduction

Plants are perpetually plants consist of novel phytochemicals, which acts as a potential anticancer agent. Plant derived products are safe, simple, eco friendly when compared to conventional drugs and its usage is considered as a greener way in controlling the growth of cancer cells. The biocompatibility and biodegradability have made the phytochemicals more efficient in treating cancer (1). Plants are perpetually used for health maintenance and for curing diseases. Cancer threat to humans is universal which can be prevented by the chemo preventive molecules derived from plants. The anticancer mechanisms exhibited by compounds obtained from medicinal plants include inhibition of DNA topoisomerase enzyme, antiprotease, antioxidant activity and immune system stimulation. Prevention and delaying the onset of cancer, decreasing the side effects of conventional drugs and providing nutritional or psychological support are other vital roles of plants in cancer prevention and therapy (2).

Environment friendly plants maintain the human health and generate a wealth of novel bioactive metabolites. From long since the medicinal plants are the remedies for human diseases as they possess pharmacologically significant phytochemical constituents. Various parts like leaves, bark, flowers, fruits, pods, twigs and thorns of *Prosopis juliflora* were used in the ailment of many diseases. In a review, it was reported that the species Prosopis has commercial importance for medicinal purposes since ancient times. Leaves and pods of *Prosopis* species exhibited the anticancer, antimicrobial, anti-inflammatory and antidiabetic activities which might be due to the presence of phenolic compounds, flavonoids, quinones, alkaloids and tannins (1). *P. juliflora* is the most predominant species of the genus *Prosopis* and it is the resource of phyto compounds which have immense pharmacological significance and hence used in treatment for various diseases (2). *P. juliflora* is found all over the world specifically in semiarid and arid areas (3). The diversified phyto constituents in *P. juliflora* has numerous medicinal properties (4).

P. juliflora is also called as mesquite or Velayati babul. It belongs the family Fabaceae and Mimosoideae subfamily. *P. juliflora* is thorny deciduous plant which is drought resistant and fast growing. Although it is a weed, *P. juliflora* is well known for its ethnobotanical significance. Majority of the population utilize these plants as traditional medicine due to its less side effects and easy availability making Mesquite one of the economically and ecologically significant plants. (3, 5, 6).

P. juliflora is found in arid and semiarid regions of India and different parts of the plant are rich in secondary metabolites which make it more therapeutically potential. The secondary metabolites of leaf extracts of *P. juliflora* were helpful in protection against chronic diseases. And it was used as treatment for cold, measles, inflammation, diarrhoea, dysentery, sore throat and flu. It is a rich source of piperidine alkaloids (7, 8). *P. juliflora* was first introduced into India about 130 years ago, the plant had folkloric use in managing inflammation and its native to tropical America but is naturalized in many countries including Egypt and India (9, 10).

P. juliflora belong to the family Fabaceae and

Mimosoideae subfamily. It is also known as mesquite (Fig. 1). It is thorny deciduous plant which is drought resistant and fast growing. *P. juliflora* is a well-known traditional medicine for its ethnobotanical significance. Mesquite is one of the economically and ecologically significant plants (6, 7). About 130 years ago, *P. juliflora* was first introduced into India. The plant had folkloric use in managing inflammation (10). *P. juliflora* is the most predominant species of the genus *Prosopis* and it is the resource of phytocompounds which have immense pharmacological significance and hence used in treatment for various diseases (3).

P. juliflora is found in arid and semiarid regions of India and different parts of the plant are rich in secondary metabolites which make it more therapeutically potential. The secondary metabolites of leaf extracts of *P. juliflora* were helpful in protection against chronic diseases. And as a folkloric medicine, it was used as treatment for cold, measles, inflammation, diarrhoea, dysentery, sore throat and flu. It is a rich source of piperidine alkaloids (8, 9). Two alkaloids were isolated from *P. juliflora* bark which were named as 1, 3- Oxojuliprosopae and Secojuliprosopinal. Apart from the pharmacological benefits of *P. juliflora*, the other benefits include promotion of nitrogen fixation, biopesticides, feed for livestock, soil amelioration, honey and wax, etc (13). From *P. juliflora* bark extracts, two alkaloids were isolated and characterized, namely 3'-Oxo-juliprosopine and Secojuliprosopinal (14).

The diversified phytoconstituents in *P. juliflora* has numerous medicinal properties (5). Alkaloids are the interesting naturally occurring substances which contribute the therapeutic potential of medicinal plants, one such alkaloid named juliflorine present in *P. juliflora* displayed antibacterial activity. And *P. juliflora* was found to contain cytotoxic principles (6). Not only alkaloids, but several other phytochemicals were also isolated from *P. juliflora* which include the flavones glycoside Patulitrin, Procyanidin, Prosogerin D, ellagic acid and tannin (15).

The wide range of applicability confirms the importance of *P. juliflora* as folk medicine and it is considered as neighbourhood plant. And it could be used as a mouth rinse due its effective antibacterial action against the oral pathogens (16). Even at lower concentrations, Mimosaceae plants like *P. juliflora* were found to have maximum efficacy against all the types of microbes (6).

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Not only alkaloids, but several other phytochemicals were also isolated from *P. juliflora* which include the flavones glycoside Patulitrin, Procyanidin, Prosogerin D, ellagic acid and tannin (14). The wide range of applicability confirms the importance of *P. juliflora* as folk medicine and it is considered as neighbourhood plant and it could be used as a mouth rinse due its effective antibacterial action against the oral pathogens (15). Even at lower concentrations, Mimosaceae plants like *P. juliflora* were found to have maximum efficacy against all the types of microbes (16).

Phytochemical profile of *Prosopis juliflora*

The extracts of leaves, root, stem, flower and pods of *P. juliflora* exhibited secondary metabolites especially glycosides, tannins, phenolics, alkaloids, terpenes, flavonoids and steroids. And the leaf extract was found to be the richest source of the bioactive principle (7). Secondary metabolites like alkaloids, steroids, flavonoids, phenolics, terpenes and volatile oils play a vital role in antioxidant, antibacterial and anticancer activities of *P. juliflora* (14) as mentioned in Fig. 1 and Table 1.

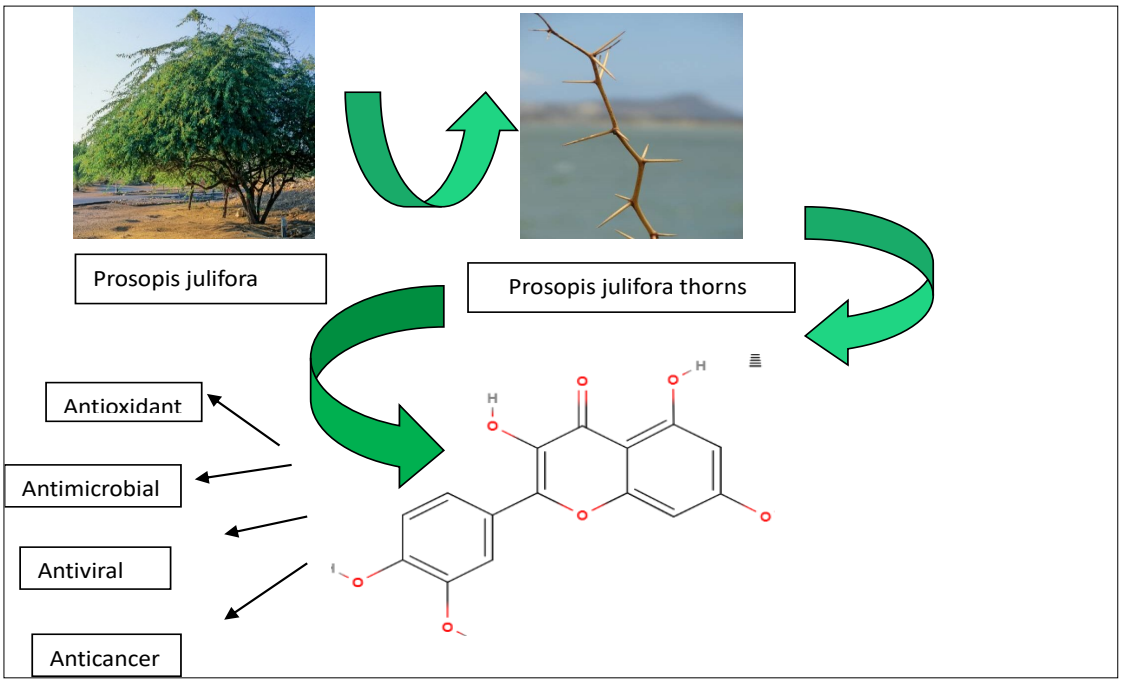

Fig. 1. *P. julifora*: an immense source of biomedical compounds.

Table 1. Phytochemical analysis of *P. julifora* leaf extracts

Sl. No.	Phytochemicals	Ethanolic extracts	Aqueous extracts
1	Flavonoids	+	+
2	Steroids	+	-
3	Tannins	-	+
4	Saponins	+	+
5	Glycosides	+	+
6	Alkaloids	+	+
7	Terpenoids	+	+
8	Anthraquinones	-	-
9	Coumarins	+	+

+ → PRESENT - → ABSENT

P. juliflora leaves showed the presence of tannins, glycosides, alkaloids, flavonoids, phenolics, saponins, carbohydrates and steroids in the preliminary screening of phytochemicals as given in Table 2 and 3 (9, 10, 17). Presence of piperidine alkaloids was reported in *P. juliflora* leaf extracts by GCMS (18). The free radical scavenging ability of *P. juliflora* leaf extracts is due to the presence of the bioactive compounds like tannins, flavonoids, alkaloids, phenolic compounds and saponins (19). Previous findings reported that *P. juliflora* leaves were enriched source of alkaloids, flavonoids, saponins which contributes to the anticancer, antioxidant and antimicrobial activity respectively (20).

Flavonoids were isolated from the heartwood of *P. juliflora* and was the antioxidant source from a renewable origin (21). Methanolic bark extracts of *P. juliflora* exhibited the presence of alkaloids, tannins, saponins, steroids, glycosides and carbohydrates (13). *P. juliflora* pod extracts indicated that the alkaloids may be responsible for its cytotoxic activity (22). Ethanolic extracts of *P. juliflora* pods exhibited anticancer property and the presence of bioactive compound terpenoid (23).

Biomedical properties of *Prosopis juliflora*

Antioxidant activity

Antioxidants studies are most important for the research in preventing chronic diseases. DPPH scavenging activity of the phenolic extracts of *P. juliflora* leaves increased with the increasing concentration (24). The methanolic leaf extracts of *P. juliflora* (Swartz) DC showed significant radical scavenging activity (16). *P. juliflora* leaf extracts showed a moderate level of nitric oxide scavenging activity and the reason for the antioxidant activity would be due to the presence of phenolics and flavonoids (25). Recent study revealed that the methanolic leaf extracts of *P. juliflora* showed higher antioxidant activity by DPPH method (26).

P. juliflora roots showed maximum antioxidant activity than the leaves by DPPH method and also indicated that a correlation existed between total phenolic, flavonoid content and antioxidant activity (27). Crude extracts of *P. juliflora* reported to contain flavanols which were responsible for the strong antioxidant activities (28).

P. juliflora thorn extract exhibited antioxidant activity and the phytochemicals present in it would have attributed for the activity (29). The results of a study reported that the phytoconstituents of methanolic bark extract of *P. juliflora* can inhibit the oxidative effect of free radicals and attribute to the antioxidant activity (30).

Table 2. Phytocomponents of ethanolic thorn extract of *P. juliflora*

Peak No.	Retention Time (RT)	Name	Peak area %	Molecular formula	Molecular weight (MW)
1	44.900	1-Triethylsilyloxyheptadecane	12.22	$C_{23}H_{50}OSi$	370
2	45.117	4-Methyl-2,4-bis(4'-trimethylsilyloxyphenyl) pentene-1	18.88	$C_{24}H_{36}O_2Si_2$	412
3	45.167	3-Carbamyl-(14H) (E)-nor-eburnamenine (3.alpha.,15.alp ha)	5.40	$C_{19}H_{23}N_3O$	309
4	45.217	1,2-Benzisothiazol-3-amine tbdms	5.91	$C_{13}H_{20}N_2SSi$	264
5	45.333	Fenoterol, N-trifluoroacetyl-o,o,o,o-tetrakis (trimethylsilyl)deriv.	10.98	$C_{31}H_{52}F_3NO_5Si_4$	687
6	45.402	Phosphorin, 2,4,6-tris(1,1-dimethylethyl)-	12.13	$C_{17}H_{29}P$	264
7	45.808	Propane, 2-ethoxy-ether	24.66	$C_5H_{12}O$	88
8	45.867	5-Methyl-2-trimethylsilyloxy-acetophenone	9.83	$C_{12}H_{18}O_2Si$	222

Table 3. Phytocomponents of aqueous thorn extract of *P. juliflora*

Peak No.	Retention Time (RT)	Name	Peak area %	Molecular formula	Molecular weight (MW)
1	9.510	Oxalic acid, monomorpholide, propyl ester	53.69	$C_9H_{15}NO_4$	201
2	14.660	Oxalic acid, heptyl propyl ester	1.54	$C_{12}H_{22}O_4$	230
3	24.642	Oxalic acid, cyclobutyl isohexyl ester	1.43	$C_{12}H_{20}O_4$	228
4	42.592	Di-n-decylsulfone	7.93	$C_{20}H_{42}O_2S$	346
5	43.250	Cyclopropanecarbohydrazide, 2,2,3,3-tetramet	14 .27	$C_{14}H_{19}N_3O_3$	277
6	43.321	Propylphosphonic acid, di(2-ethylhexyl) ester	10.41	$C_{19}H_{41}O_3P$	348
7	46.600	Papaveroline	5.83	$C_{16}H_{13}NO_4$	283
8	46.683	Cobaltocene, 1,1'-diphenyl-	4.89	$C_{22}H_{18}Co$	341

Anti-inflammatory activity

Ethanolic leaf extracts of *P. juliflora* exhibited potent anti-inflammatory activity and it has substantiated its traditional usage against various inflammations (9). In another study it was reported that the methanolic bark extracts of *P. juliflora* exhibited significant anti-inflammatory activity which justified that it was used as folklore medicine to treat inflammation (13). The ethanolic extracts from woody stems of *P. juliflora* exhibited anti-inflammatory property (31).

Antimicrobial activity

P. juliflora is a vital source of antibacterial and antifungal compounds (14). Though being a weed, *P. juliflora* exhibited successful antifungal activity against phytopathogen and was very effective at lesser dosage compared to the synthetic fungicides (32). Also strongly supported by a literature that an alkaloid from *P. juliflora* named juliflorine exhibited antibacterial activity (11). *P. juliflora* was reported to possess both antibacterial and antifungal activity even at lower concentrations and showed remarkable activity towards Gram negative bacteria (16).

The leaf extract of *P. juliflora* was found to be effective against both aerobic and anaerobic bacterial strains like *Clostridium perfringens, Staphylococcus aureus* and *Escherichia coli* (33). *P. juliflora* is a rich source of phytocompounds and the cumulative effect of the chemical constituents present in the *P. juliflora* leaf extracts could be the reason for its antibacterial activity (5). As an alternative to antibiotics, the aqueous leaf extracts of *P. juliflora* were used against oral and periodontal pathogenic organisms and it might be due to the flavonoids like quercetin and apigenin (15).

Recent research revealed that the phenolic compounds such as tannins and flavonoids might have attributed the antimicrobial activity of *P. juliflora* extracts of leaves and roots and the mechanism behind could be cell wall disruption, complex formation with cell wall (27). It was reported in a study that the ethanolic leaf extracts of *P. juliflora* leaf and bark extracts showed antibacterial activity in a concentration dependent manner and it was also mentioned that the phytochemicals were responsible for the same (34). A broad spectrum antibacterial activity was exhibited by *P. juliflora* bark extracts (12).

Notable antibacterial activity against medically important strains were observed, among which *Staphylococcus aureus* was more susceptible and *Pseudomonas aeruginosa* was least susceptible towards the leaf extracts of *P. juliflora* (10). It was documented in a previous study that the ethanolic extracts of leaf, pod and flower of *P. juliflora* displayed strong antibacterial activity against both Gram positive and Gram negative bacteria and the piperidine alkaloids were responsible for the activity (8). Pods of *P. juliflora* have shown antibacterial activity (6). *P. juliflora* seed pod extracts exhibited more susceptibility towards Gram positive organisms than Gram negative organisms which is due to the type of outer membrane and construction of cell wall (2).

Anticancer activity

Higher content of flavonoids in *P. juliflora* Swartz DC makes it a novel source for anticancer and antioxidant property. In addition to that, tannins and phenols were synergistic towards the action of flavonoids (20). Medicinally important terpenoids present in the *P. juliflora* pods were the potent source of anticancer and chemo preventive properties (23).

P. juliflora leaf alkaloids were dose and time dependent and exhibited significantly lesser growth inhibition on normal cell lines when compared to human T- cell leukaemia (MOLT-4) cells (35). Previous *in vitro* study reported that the total phenolic extract of *P. juliflora* possessed strong anti-proliferative effect against the tumour cell lines by MTT test. The cytotoxic potential of the extract was significantly higher on the cancer cells such as T-cell leukaemia (MOLT-4), oral carcinoma (Oral (KB) and cervical carcinoma (HeLa) than that of the normal cell lines such as T-lymphocytes, oral fibroblast (Tig-7) and Chinese hamster ovary (CHO) (24).

It was mentioned in a study that the Mesquite (*P. juliflora*) seed lectin exhibited antiproliferative activity against HeLa cell lines but not against normal cells (36). Alkaloid rich fraction of *P. juliflora* pod revealed *in-vitro* ovicidal activity against gastrointestinal nematodes of goat and cytotoxicity on Vero cell lines (22). Recently in a study it was mentioned that the methanolic leaf extract of *P. juliflora* exhibited maximum activity against Cervical cancer (HeLa) cell line, suggesting that *P. juliflora* is a potent anticancer plant (26). A study revealed that the methanolic extracts of whole plant of *P. juliflora* showed higher cytotoxicity percentage against HCT 116 cell lines (37). Varying degrees of cytotoxicity was observed in the methanolic and petroleum ether extracts of *P. juliflora* leaves for Vero cell lines (38). A new compound was isolated from flowers of *P. juliflora,* which played an important role in the cytotoxic and antiproliferative effect on *Allium cepa* cells (39).

Conclusion

Plants are the largest storehouse of the bioactive compounds. The bioprospecting of plants will be helpful for many pharmaceutical firms. Though *P. juliflora* was considered as notorious weed plant, it has widespread usage as a traditional medicine. This review includes the biomedical properties of *P. juliflora* like antioxidant, anti-inflammatory, antimicrobial and anticancer properties contributed by the phytochemicals. The pleiotropic action of the phytochemical entities makes it very much suitable for drug development. Development of safe drugs with higher efficacy from the plant sources is the need of the hour. Also, inexpensive drugs could emerge for the treatment of various diseases which helps in increasing the affordability even for a common man, thereby improving the quality of human life.

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Authors' contributions

DA participated in overall conceptualization and manuscript writing. KAS and KBS provided software and editing of the article. All the authors reviewed the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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